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**ECONOMICS AND TERMINAL AREA ENVIRONMENTAL
IMPACT OF STOL TRANSPORTATION**

Elwood C. Stewart

**Ames Research Center
Moffett Field, Calif. 94035**

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ENVIRONMENTAL IMPACT OF
STOL TRANSPORTATION

Elwood C. Stewart
Ames Research Center, NASA
Moffett Field, California 94035

INTRODUCTION

Some interim results on a systems study of STOL Transportation will be discussed in this paper. These results are based on a study being done by The Aerospace Corporation for the Ames Research Center. However, since the study is not yet complete, the discussion will be in the nature of a progress report. An attempt will be made to present an overview of the study and its objectives, and some of the results that are beginning to emerge.

The systems study to be discussed herein concerns the question of the impact of advanced STOL aircraft in meeting the needs of a short-haul transportation system. By careful consideration of the objectives which the short-haul system should achieve, it is believed evaluation should be made in terms of the following criteria:

- (1) Service to the passenger
- (2) Economic viability
- (3) Terminal area environmental criteria:
 - a. Community noise
 - b. Ground and air decongestion
 - c. Air pollution

The first item, service to the passenger, is best measured in terms of the number of passengers the system will attract, and is of obvious importance if the system is to serve a useful purpose. Economic viability is readily measured in terms of the return on investment (ROI); interest will center on different levels of return on investment in order to cover the range between the maximum level permitted by regulating agencies and a low level which would correspond to subsidized operation. The terminal area environmental criteria to be considered include the impact of STOL system noise on the community surrounding the airports, the ground and air decongestion which might be achieved at the major CTOL hubs, and the effect on air pollution.

METHODOLOGY

To accomplish the preceding objectives, the characteristics of the advanced STOL aircraft and its operational capabilities will be of obvious importance and interest. However, this is clearly not sufficient, since the aircraft is only part of a much larger system with which it must interface. This larger system, which is to be considered in the analysis, is shown in figure 1. On the left is the transportation system with its

major components, the traveler, the existing transportation, and the proposed new STOL system. The first step in the methodology involves modeling these components of the transportation system, followed by an arena analysis. A description of these topics is beyond the intended scope here, but it is important to note that the analysis is based on a competitive situation between various combinations of modes in which the traveler is assumed to select the least-cost alternative (including value of time). Although a great many results of interest can be obtained from the analysis, our interest will center here on the STOL system performance. For this purpose the three figures of merit or criteria discussed earlier are shown for the STOL system. The unique feature of the methodology to be used here is that three of the figures of merit, passengers carried, return on investment, and noise impact, are used as feedbacks to the STOL system. The remaining two figures of merit, congestion and pollution, are merely evaluated since it is anticipated they will be benefits which will increase with the number of passengers carried. The three feedback loops are used in an optimization procedure to alter all of the available STOL system parameters so as to achieve a desired objective. This objective is to maximize the number of passengers carried with a constraint on the return on investment. The noise impact is inherently included in the optimization through the economics as will be discussed later.

The STOL system parameters which can be utilized to accomplish the optimization are important to note. They consist of the following:

- (1) aircraft concept
- (2) aircraft size
- (3) fleet size
- (4) changes in aircraft technology
- (5) curved, steep flight paths
- (6) location of STOL ports
- (7) service paths
- (8) land use
- (9) fare levels

Most of these variables are self explanatory. The first five are concerned with the aircraft and its capabilities; item (4) refers to technological changes such as reduced noise, reduced field length capability etc. In item (7), service paths refers to a route between any two ports. Item (8) is intended to represent the use of land surrounding the airport so as to be compatible with the actual noise levels.

GUIDELINES

There are several important guidelines for the study which need discussion. First, the study is directed toward a 1980 time period to correspond to the time at which the congestion problem is predicted to become critical. Second, the STOL system will be assumed to utilize existing general aviation airports or perhaps new airports if necessary. Thus the STOL system operates independently of the major hubs which currently process the short-haul traffic. For this reason we would expect some degree of decongestion of the major hubs. Third, various ground costs are charged to the STOL system economics. These include new or improved terminals to process the

passenger demand determined by the optimization analysis, new or improved runways to handle the number and sizes of aircraft determined by the analysis, and the cost of noise buffer zones surrounding the airport so as to be compatible with the noise levels. And finally, the noise is to be measured by NEF, or noise exposure factor, corresponding to generally accepted practice in the United States and Europe.

The arenas to which the analysis is being applied are illustrated in figure 2. As can be seen there they consist of four cities in the California Corridor, three cities in the Midwest Triangle, and four cities in the Northeast Corridor. These arenas have been selected because they cover the spectrum of travel patterns likely to be encountered in the United States. Figure 3 illustrates the differences in these travel patterns.

The STOL aircraft to be used in the short-haul system studies are intended to cover a variety of parametric changes. In this paper, however, the results for one particular aircraft will be given. Some of its characteristics are shown in figure 4.

PRELIMINARY RESULTS

With the preceding as background, some of the preliminary results of the optimization analysis utilizing the above STOL aircraft in the California Corridor can now be discussed. Of importance will be the various figures of merit shown in figure 1. The first result is shown in figure 5. Here the maximum number of daily passengers (departures and arrivals) which can be carried as a function of return on investment and vehicle size, is given in carpet plot form. This plot is the result of the optimization analysis and must be interpreted carefully. Each point on the plot is an optimum point achieved by varying the STOL system parameters. For example, to achieve a 7.5% return on investment with a 100-passenger aircraft, all of the available STOL system parameters have been varied to attract the maximum number of passengers, in this case 22,000 per day. Along the 100-passenger capacity line, the number of passengers carried decreases as the return on investment increases. This is because for example, the optimum fare increases and the optimum fleet size decreases in order to meet the increased return on investment. It might be noted that the discontinuity in the plot is due to the required addition of a third crew member.

There are several significant observations to be made from figure 5. With regard to vehicle size, it can be seen that the results are relatively insensitive to vehicle capacities between 100 and 200. This is important because it allows freedom to base the choice of vehicle size on other considerations. For example, from the community acceptance viewpoint the smaller 100-passenger aircraft might be preferable. Another observation is that positive values of return on investment are achieved. The 7.5% line is typical of what is actually achieved by successful short-haul air carriers, while the 10.5% line represents an upper bound established by the Public Utilities Commission. The effect of subsidizing the operation has a significant effect on increasing the number of passengers carried as can be seen by the lines for lower return on investment. A final observation is that the number of passengers which the STOL system can attract is substantial. How substantial is best answered by comparison with the traffic carried by the other modes, that is, by examining the modal split.

The modal split between the various modes will be illustrated for the point in figure 5 corresponding to the 10.5% return on investment and the 200 passenger aircraft. The result for the Los Angeles-San Francisco part of the California Corridor both with and without STOL is shown in figure 6. Here it is seen that the STOL system has captured about 1/3 of the total traffic, and that there has been little impact on car, rail, and bus traffic. The major impact is on the CTOL mode, and this traffic has been reduced by about a factor of 3. This reduction is believed to be beneficial to the CTOL ports. It might be interpreted as a decongestion effect, although a better interpretation would be that this reduction in short-haul CTOL traffic represents available capacity that can be used to meet the increasing long-haul demand expected in the early 1980's. This beneficial effect on the CTOL ports would be magnified when the aircraft rather than passenger traffic is considered. For example, the elimination of a short-haul aircraft from the CTOL hub would mean that a much larger long-haul aircraft could be used, and that the passenger carrying capacity of the CTOL hub would be correspondingly increased. It is clear, however, that a more thorough evaluation of the effect on the CTOL ports is required.

The modal split effects just discussed are conservative from the viewpoint that the return on investment was 10.5%. These effects are more pronounced when the return on investment is decreased to a lower figure of 8%. Results for this case indicate that the STOL system would then capture 38% of the total, while the CTOL short-haul traffic would be reduced by a factor of 4.

Next some results obtained regarding community noise impact will be discussed. Two approaches based on different assumptions are being considered. One assumption is that noise buffer zones can be purchased so that the land use will be compatible with the actual noise levels. An alternate assumption is that such noise buffers cannot be purchased due to the social and environmental restrictions.

Based on the first assumption that noise buffer zones are to be purchased, an examination is being made of the noise impact on the total system. To illustrate the methodology being used and the results emerging, an example airport, the Concord-Buchanan airport, is shown in figure 7. Here are shown the airport boundary, the two runways, and the surrounding zoning pattern as indicated by the codes. Each of the irregular-shaped areas corresponds to a different land value, with the higher-priced residential land being generally in the southwestern portion of the map. Also shown in the figure is the general aviation straight-line flight pattern, landing from the north and departing toward the south. A curved STOL flight pattern which has been determined to be desirable for minimum noise impact is indicated by the approach coming from the northwest and departing to the west, thus largely avoiding the planned residential zones. This STOL path also descends at a steep angle of 7.5° and departs at 10°. From these paths and the mix of aircraft, it is possible to determine the various NEF noise contours of interest, namely 30, 35, and 40 NEF corresponding to acceptable levels for residential, commercial, and manufacturing uses respectively. These contours when superimposed on the land zones enables one to determine the total dollar value of the land (excluding the airport) for which the acceptable noise levels are exceeded. This is the manner in which the noise impact is used in the feedback loop shown in figure 1.

Results of the noise analysis just described are given in figure 8. The impact of the projected general aviation operations for 1980 is shown as the horizontal line and is about \$3 million dollars. The effect of superimposing STOL operations is indicated by the two lowest curves. Note that the effect of aircraft size and number of operations over the entire range shown have a small dollar impact compared to the general aviation impact. The number of operations actually required as determined by the optimization analysis indicated 10 daily operations would be sufficient at this port; even the busiest ports required no more than 40 operations. Thus for the required number of operations the impact is only a fraction of a million dollars. The effect of increasing the noise level by 6 EPNdB does not increase the impact greatly over the ranges cited.

There are several reasons which account for these results. First the single-flight noise contours in terms of EPNdB are small as a result of: (a) the basically quiet aircraft characterized by the noise levels in figure 4, and (b) the steep flight paths possible with the STOL aircraft. The steep flight paths for ascent or descent tend to widen the noise contours rather than lengthening them as with conventional flight paths so that the noise contours tend to be confined better to the airport boundaries. Second, the effect of multiple operations on the NEF contours is small because the number of operations required to optimize the total system performance is small.

The dollar impact can be put in perhaps better perspective by comparing these noise impact costs to the total system costs. Total system costs for a system optimized for a 100-passenger-size aircraft have been determined so as to include the total aircraft fleet costs, the terminal costs, and costs for airfield improvements or new airfields. Such costs are in excess of \$200 million so that the noise impact costs are small in comparison.

The above results alone are obviously not conclusive because of the port dependent nature of the results. Although the same pattern is emerging for some of the other ports used in this study, these preliminary conclusions regarding noise impact should be interpreted cautiously until the analysis for all ports is complete.

Regarding the second assumption that noise buffer zones cannot be purchased, only a preliminary examination has been made. From an analysis of 115 existing general aviation airports in the California Corridor and Midwest Triangle, the number of airports which would just enclose the 95 EPNdB noise contour has been determined, and the results are shown in figure 9. Here the number of such ports is shown as a function of the field length capability of the aircraft. Aircraft requiring long field lengths have relatively long noise footprints. As field length capability is shortened the footprint becomes smaller, and more ports would contain the noise footprint so that the curve rises. Note that even at 1500 feet (457 meters) aircraft capability, there are still nearly half of the ports which would not enclose the noise contour. The number of ports required and the corresponding field length capability of the aircraft can be determined only by a total system analysis in the context of figure 1. However, it is clear that the information of figure 9 would be an input to the systems study. For example the number of ports available (the ordinate) would influence the convenience of the STOL system to the traveler, and hence ultimately affect the figures of merit in figure 1, that is, the passenger carrying capability and the economic viability. The aircraft field length capability (the abscissa) would influence the economics of the systems analysis because of the greater cost to achieve shorter field length

capability. Thus the best point to choose in figure 9 needs further study in which the information of figure 9 is incorporated into the complete systems analysis illustrated in figure 1.

PRELIMINARY CONCLUSIONS

The preliminary conclusions that have been reached thus far in the study for a 1980 short-haul system in the California Corridor can be itemized as follows:

- (1) Attainable STOL technology could result in a short-haul transportation system which is economically viable and which would attract a large number of people.
- (2) Aircraft sizes between 100 and 200 have small effect on passenger demand.
- (3) Under the assumption that noise buffers can be purchased for compatible land use, preliminary results indicate noise impact costs for 95 EPNdB aircraft are negligible compared to the general aviation impact and the other STOL system costs. However, analysis for all the ports in the various arenas needs to be completed before definitive conclusions can be drawn.
- (4) Under the assumption that noise buffers cannot be purchased due to social and environmental restrictions, port availability and very short field length aircraft capability may be critical issues, and need further study.
- (5) The required volume of STOL traffic at the general aviation airports is small. Large increases in the number of operations could accommodate future short-haul demand growth in the 1980's.
- (6) The STOL system would enable a significant expansion in the long-haul traffic from major CTOL hubs.

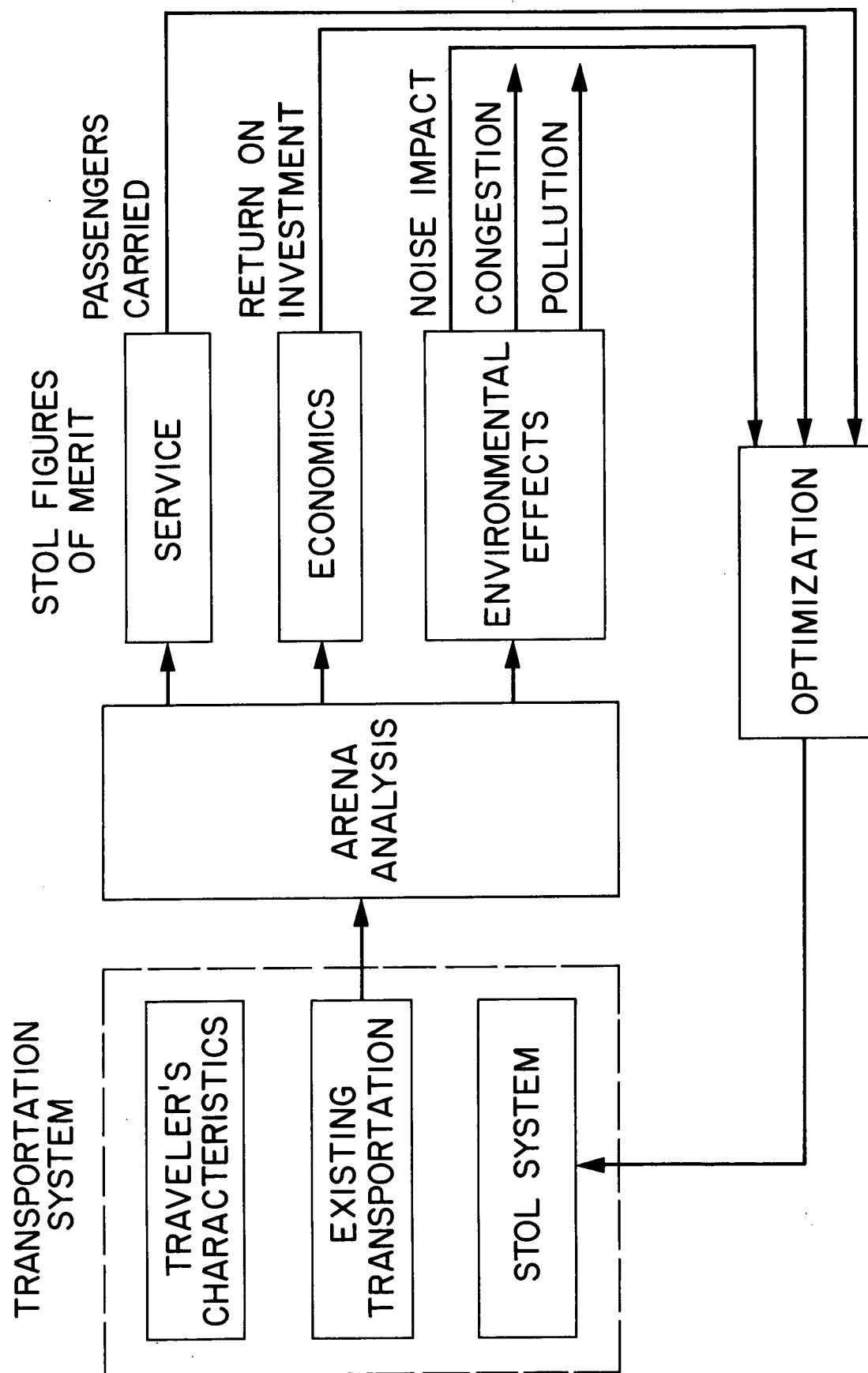


Figure 1. -- System study methodology.

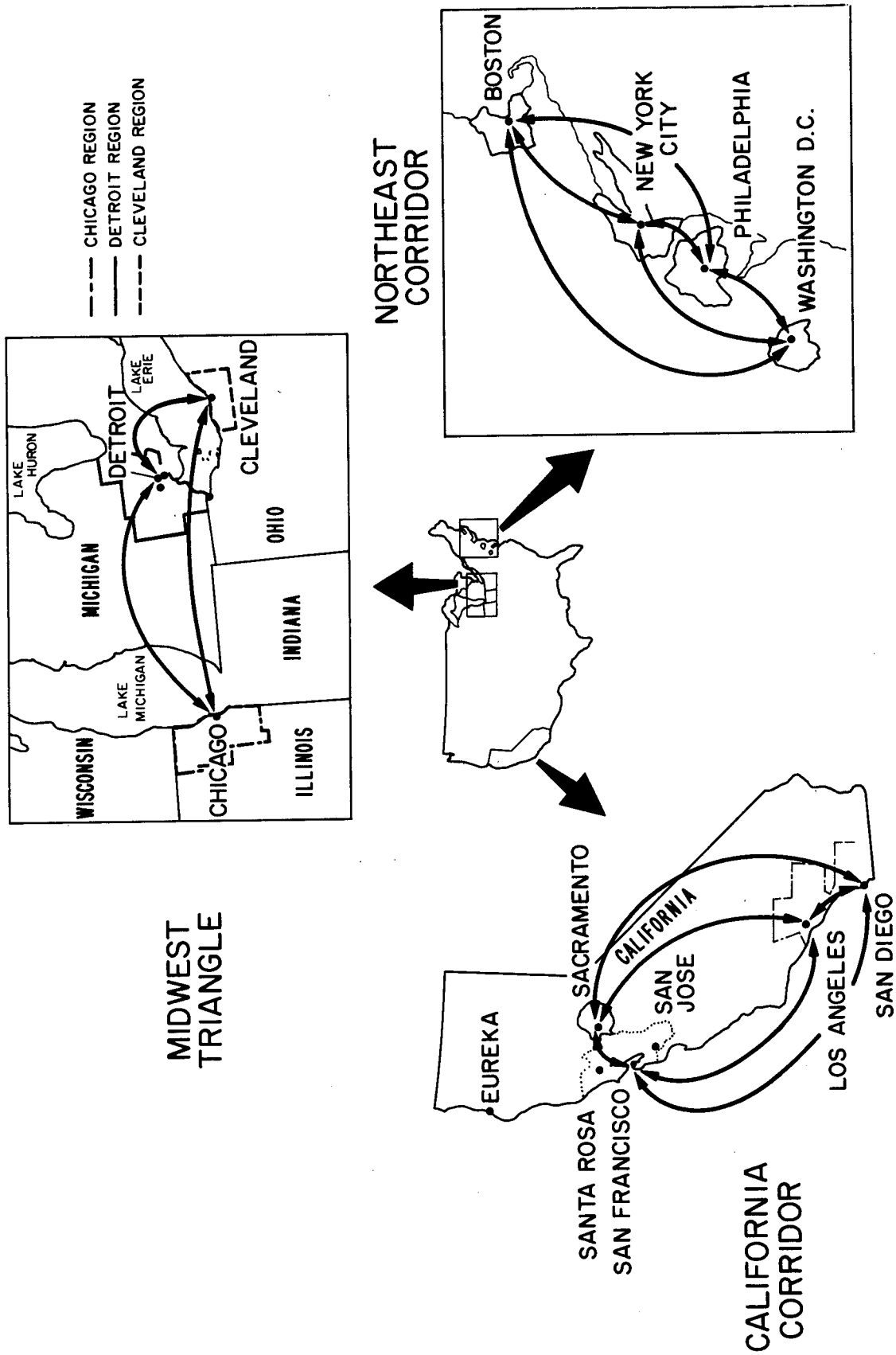


Figure 2. - Short-haul STOL transportation system study arenas.

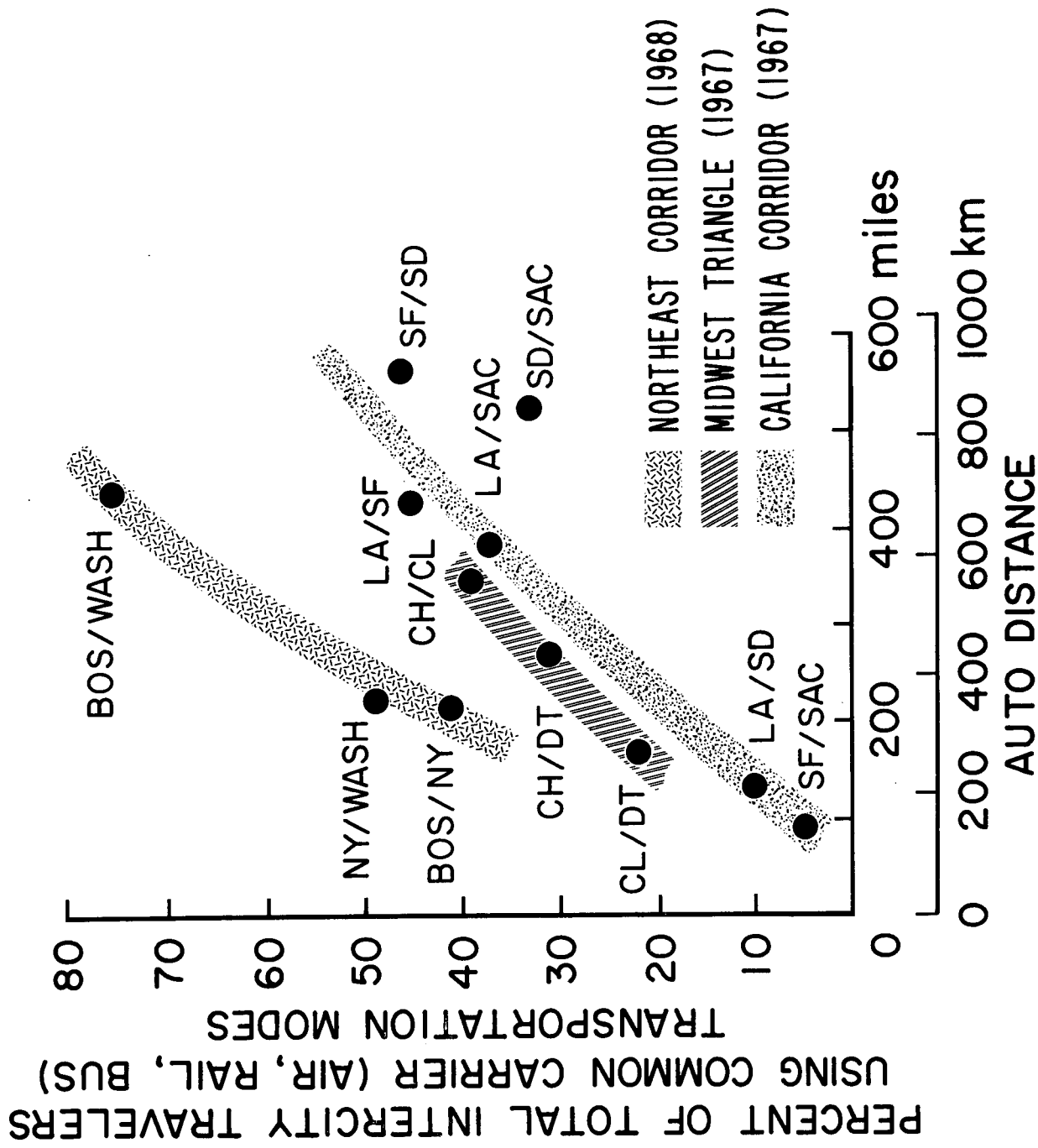


Figure 3. - Arena travel pattern comparisons.

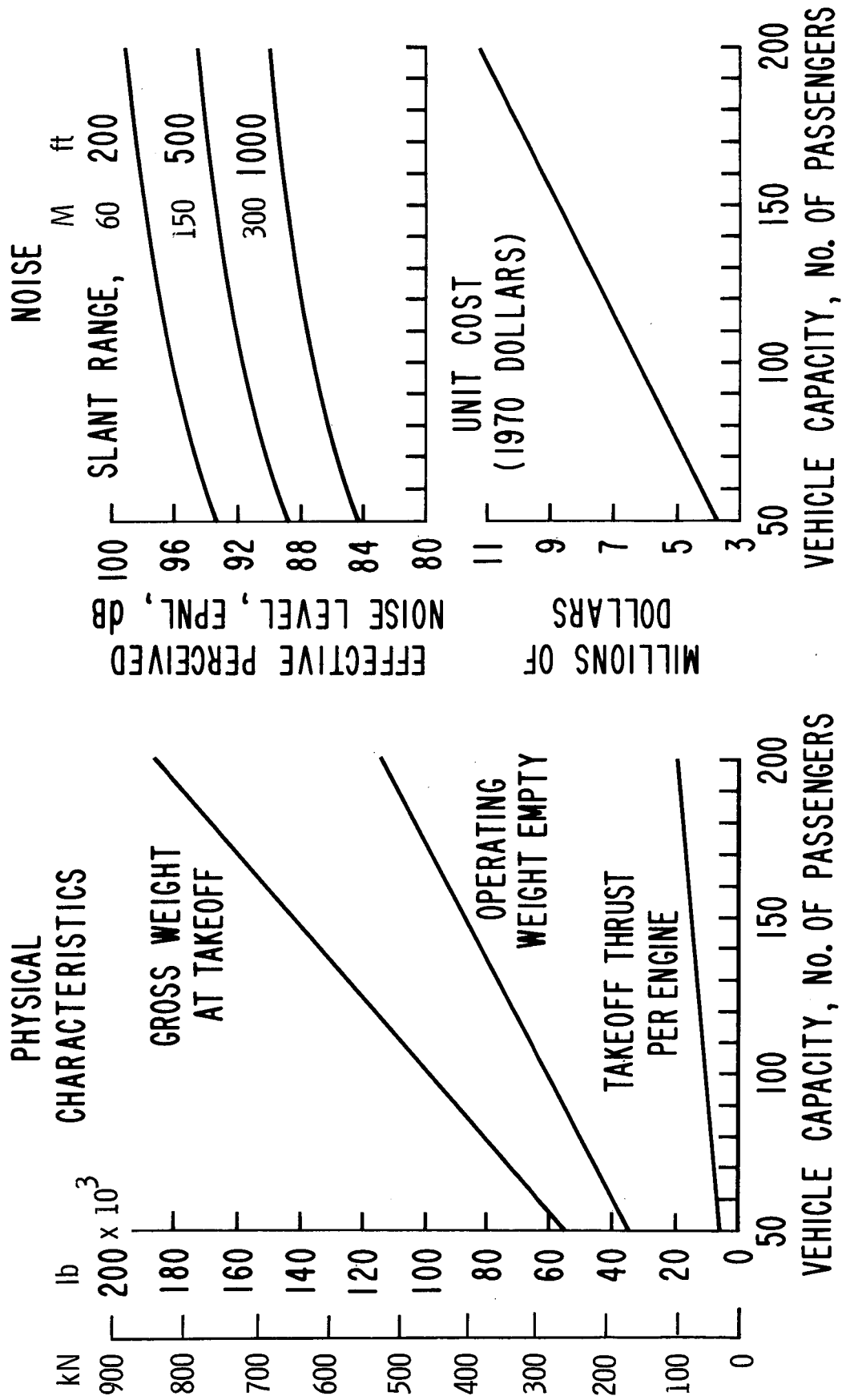


Figure 4. - Variation of aircraft characteristics with capacity.

CALIFORNIA CORRIDOR

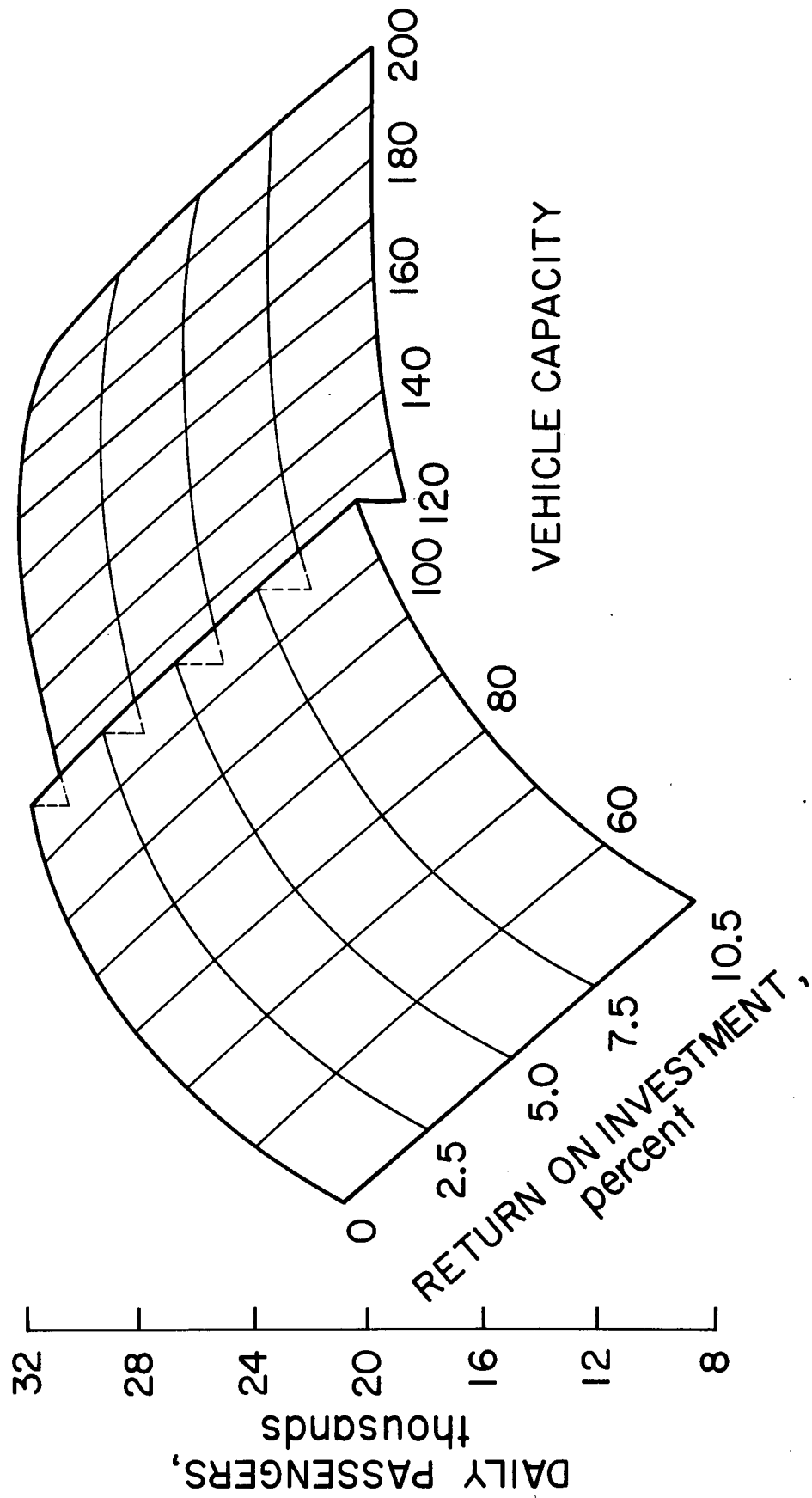
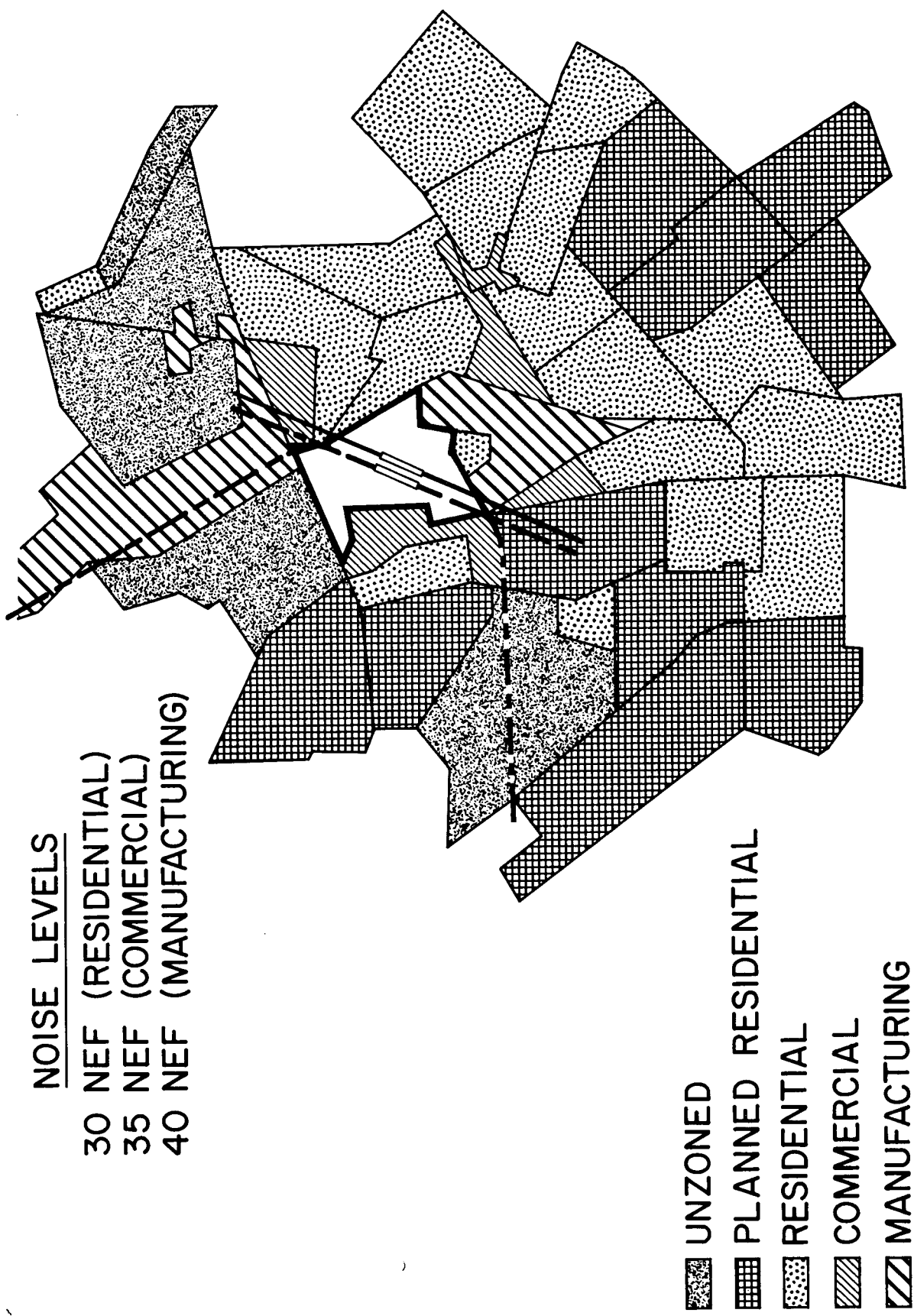


Figure 5. - Effect of vehicle capacity and return on investment on passenger patronage.

EXAMPLE RESULTS FOR LOS ANGELES--SAN FRANCISCO
 200 PASSENGERS ROI = 10.5%

MODE	ONE-WAY FARE	PASSENGER TRIPS PER DAY	
		WITHOUT STOL	WITH STOL
STOL	17.94	—	12,290
CTOL	16.50	16,510	5,760
CAR	—	20,740	19,580
BUS	13.50	770	580
RAIL	16.00	380	190
TOTAL		38,400	38,400

Figure 6. - Impact of STOL on 1980 modal split.



NOISE LEVELS

- 30 NEF (RESIDENTIAL)
- 35 NEF (COMMERCIAL)
- 40 NEF (MANUFACTURING)

- UNZONED
- PLANNED RESIDENTIAL
- RESIDENTIAL
- COMMERCIAL
- MANUFACTURING

Figure 7. - Concord-Buchanan Airport surrounding land use zones with STOL and CTOL routes.

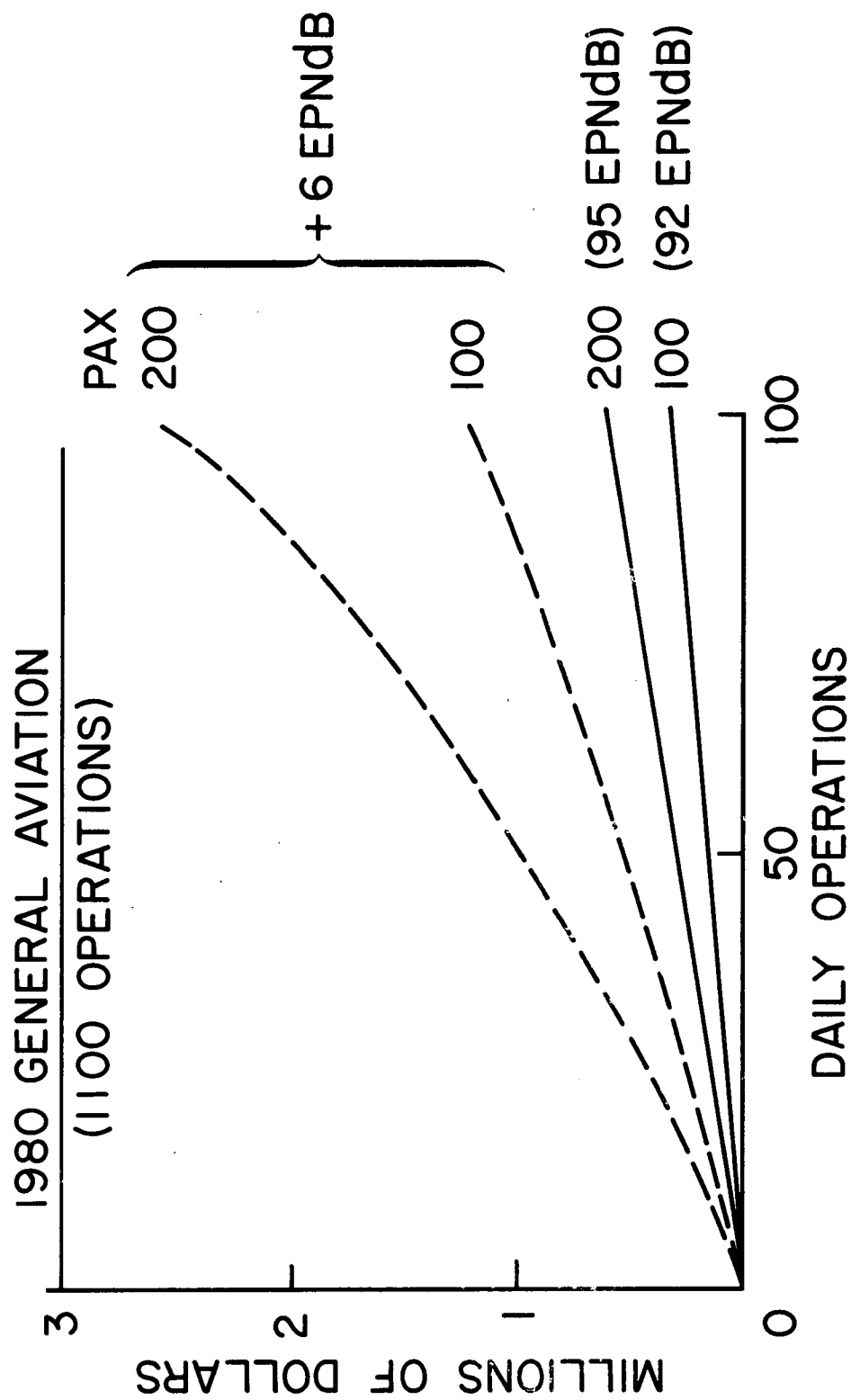
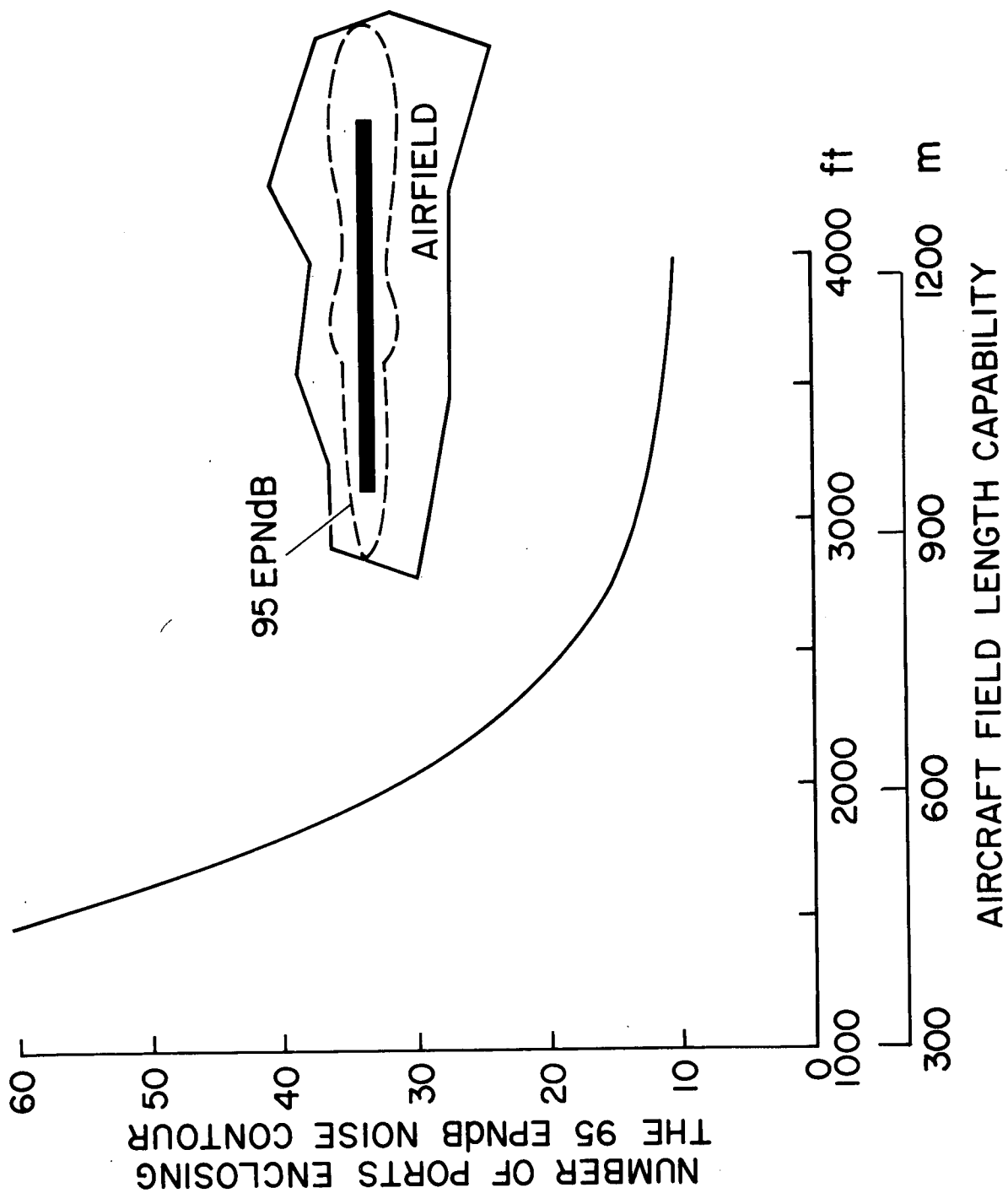


Figure 8. - Dollar value of noise-impacted land for Concord-Buchanan Airport.



NOTE: 115 AIRFIELDS IN CALIFORNIA CORRIDOR AND MIDWEST TRIANGLE

Figure 9. - Availability of STOLPORTS with low noise impact.